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THE AUTHORIZED PLAN OF DEVELOPMENT OF THE MISSOURI RIVER BASIN

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FOREWORD

There has been a great deal of discussion of recent months about the development of the Missouri River Basin. Much of this discussion appears to ignore the fact that there is now authorized by Congressional action a carefully laid out, coordinated, and comprehensive plan for this development. We have accordingly undertaken to present in brief form some of the significant factors leading up to that plan and its authorization. A condensed engineering description of the physical features of the plan is also given. It should be pointed out that we have endeavored to present as impartial a description of the several issues involved as our sources of information permit; however, should there appear to be any bias, it is the writer's own, and does not intentionally reflect the policies of any agency or organization referred to. A brief bibliography of official and semi-official publications is given for the convenience of those who wish to pursue the matter further than is appropriate for this article.

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GENERAL DESCRIPTION

GEOGRAPHY: The Missouri River Basin covers a vast area of the Mid-West. It extends from Canada on the north halfway through Colorado, Kansas, and Missouri on the south; from western Montana and Wyoming on the west to Minnesota and Iowa on the east. It includes all of the state of Nebraska, almost all of South Dakota, and the greater part of North Dakota. The total area is 529,350 square miles, of which about 2 per cent, or 9,715 square miles, lies in Canada. The balance, 519,635 square miles, constitutes approximately one-sixth of the land area of the United States.

The stream which drains this area is formed at Three Forks, Montana, by the confluence of the Jefferson, Madison, and Gallatin Rivers. From its source it flows approximately 260 miles east-northeast to the vicinity of Fort Benton, Mont., thence approximately 564 miles practically due eastward to the vicinity of Williston, N. Dak. From this point it swings southward in a great arc past Bismark, N. Dak., and Pierre, S. Dak., and flows generally south-southeastward to Kansas City, Mo., approximately 1,330 miles below Williston. From Kansas City it flows generally eastward and a little south to its mouth on the Mississippi River a few miles above St. Louis, Mo. The total length of the Missouri River is approximately 2,550 river miles.

Even small rains produce flash floods and much erosion on lands like these. Picture from Civil Engineering, March 1945.

From a steep mountain stream in its upper reaches, the Missouri becomes, in the lower reaches, one of the great alluvial rivers of the world, carrying a heavy silt load and, in its wild state, winding at will through a broad, flat flood plain. The valley through which it flows changes in a corresponding manner. In the mountains of western Montana the slope is steep, averaging 5.4 feet per mile above Fort Benton. There are numerous gorges and waterfalls affording sites for high-head hydroelectric power development. Agricultural activity is limited to narrow tracts under the canyon walls.

Below Fort Benton the Missouri River enters the Great Plains, through which it flows in a well defined "U"-shaped valley with rolling uplands extending from the tops of the bluffs on either side. Throughout this section of the river, which extends to the vicinity of Yankton, S. Dak., there are occasional areas of alluvial land along the valley floor, or on terrace benches, which are well adapted to crop farming. Stock farming is carried on in the uplands, with dependence for winter feed upon the valley farms. However, in some areas there are extensive bad lands, characterized by extreme gullying and severe surface erosion. Under present practices such areas are largely wasteland. Through this entire Great Plains Region the slope of the river averages 1.1 feet per mile.

In the vicinity of Yankton the Missouri River enters the Central Lowlands, and flows through a distinctly different type of valley. The valley walls recede, leaving a broad, flat, alluvial flood plain which is very fertile, and well adapted to highly diversified agricultural activity. Drainage in the uplands is better defined, and the hills also are well adapted to crop farming through wide areas. This general condition extends to the mouth of the river, although in its lower reaches it flows along the north edge of the Ozark Plateau, a region of more rugged topography and greater relief. The slope from Yankton to the mouth averages 1.0 foot per mile.

The most important headwater tributary of the Missouri, the Yellowstone River, rises in Yellowstone Lake among the mountains of Wyoming and, behaving much like the main stem, flows in a northeastward direction down out of the mountain canyons into the Great Plains to its mouth just below the Montana-North Dakota state line.

The next large tributary, the Platte River, is formed by the confluence of the North Platte and South Platte rivers in central Nebraska; these streams rise in the mountains of central Wyoming and central Colorado, respectively. Here again the behavior of the main stem is closely reproduced. The North Platte and the South Platte flow down out of the mountains in generally eastward courses to their junction just east of North Platte, Nebr., well out in the Great Plains; thence the Platte flows on eastward toward the Central Lowlands and its entry into the Missouri at Plattsmouth, Nebr., a few miles below Omaha, Nebr.

The third large tributary, the Kansas River, is formed by the confluence of the Smoky Hill River and the Republican River at Junction City, Kans., which lies between the Great Plains on the west and the Central Lowlands on the east. Both of these streams rise in eastern

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Colorado, and flow generally eastward across the Great Plains; from their junction the Kansas River continues in an eastward course through the Central Lowlands to its mouth at Kansas City, Kans.

The remaining tributaries include the Milk River, an important international stream between Canada and northern Montana; the little Missouri River of western North Dakota; the minor western tributaries of North and South Dakota, the Heart, Cannonball, Grand, Moreau, Cheyenne, Bad, and White rivers; the sandhill draining Niobrara River; the James River, which possesses the dubious distinction of being the world's flattest stream; the Big and Little Sioux rivers, which early records indicate were once thought to be one stream; and the Osage River of the Ozarks, which Kansas insists upon calling the Marias de Cygne.

GEOLOGY: The Missouri River Basin forms an interesting study for the historical geologist. It is believed that in pre-glacial times the upper Missouri, the Yellowstone, and the Little Missouri rivers all flowed eastward and northward to enter the McKenzie River system, which drains into Hudson Bay. The present day Niobrara was then the headwater stream of the Missouri River system. However, during glacial times the successive series of ice sheets cut off this northern outlet, and forced the Montana and Wyoming drainage systems to find a new outlet to the south, along the face of the ice sheet. The James River Basin, the northern end of which probably drained northward in pre-glacial times, happened to drain southward as the glaciers receded, which is believed to account for its remarkably flat gradient. The present Missouri River from the confluence of the Yellowstone follows in a general way this recent course through the valley which it cut during glacial times, in spite of the fact that a more direct course to lower ground and to the sea lies to the north. These unusual relative elevations give rise to the possibility of diversion into the Souris River and Red River of the North basins, which are the remnants of the pre-glacial McKenzie drainage system in the United States, and into the James River basin, part of which the Missouri River captured from that system.

The lithology of the Missouri River Basin is of particular importance to the engineer, for it establishes the foundations upon which he must erect his structures, and the materials of which he may expect to build them. Along the western rim of the basin, in the headwaters of the Missouri itself, and of the Yellowstone and Platte rivers, the faulting and folding of the Rocky Mountains has exposed formations of all ages,

from recent to pre-Cambrian. Massive foundations for large structures are available, it being generally necessary only to exercise care in the avoidance of active fault planes. Excellent material for concrete aggregate is practically always available within easy distance of any project site, if not upon the site itself.

Throughout the remainder of the basin, with the exception of the Ozark Plateau and the Black Hills, comparable sites for large structures are not available. Beginning near the mouth of the Missouri River there are occasional massive limestone formations which can, under favorable conditions, be used as foundations for large structures. This is particularly true in the adjoining Ozark Plateau. Many stream aggregates are of good quality, and crushed rock is reasonably easy to obtain. Proceeding up the stream, more and more shale formations are encountered, and the channel is cut in progressively younger formations. The Niobrara Chalk, outcropping in the vicinity of the Nebraska-South Dakota state line, is the last formation capable of supporting concentrated loads of large magnitude. There are no well consolidated formations along the main stem above this region, until the mountains are reached. Heavy sloughing is evident in the bluffs, and great care must be used in the selection of the foundation for any large structure, and in the design of the structure, so that the load may be distributed enough to bring it within the unit bearing capacity of the foundation materials. Available aggregates are likewise of lower and lower quality. Throughout the Dakotas, in the areas along and south of the Missouri River, there are few sources of acceptable aggregate. North of the river there are glacial deposits which yield excellent materials, but they are somewhat erratic in occurence, and of generally insufficient quantity for large construction projects. Sound quartzite outcrops at Sioux Falls, S. Dak., and there are granite outcrops in Minnesota. This same general paucity of construction materials prevails in eastern Montana, until the mountains are reached.

The Black Hills consist of an isolated upthrust dome which has been weathered to the present mountainous topography. From the point of view of foundation formations and construction materials this area compares with the Rocky Mountain region to the west.

CLIMATE: As would be expected of so large an area, the climate over the Missouri River Basin varies widely. In the semi-arid mountainous headwater regions the average annual rainfall is as low as 6 inches in some restricted areas, with a general regional average of perhaps 15

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inches. Mean annual temperatures range from 40° to 43°, with a low of —61° and a high of 117°, both recorded in Montana. Winters are long and cold; summers are short and hot, with a growing season averaging as low as 100 days in some areas, and up to 120 and 130 days through most of the region. All of these values are subject to considerable change over short distances because of the rugged terrain with consequent large differences in elevation and the effect of mountain ranges upon the movement of air masses.

Proceeding eastward and southward down stream the climate becomes moister, varying through sub-humid as the average annual rainfall increases gradually to a regional average of about 35 to 40 inches in the vicinity of the mouth. Temperatures change little through the Dakotas, the mean annual temperatures of North and South Dakota being 40° and 46° respectively, with a low of —60° and a high of 120°, both recorded in North Dakota. The growing season in the eastern Dakotas averages about 140 days. Further south through Nebraska, Iowa, Kansas, and Missouri, temperatures rise to a mean annual of about 55° near the mouth, with a low in this region of —40° and a high of 118°, both recorded in Missouri. The growing season near the mouth averages about 185 days.

HYDROLOGY: The stream characteristcs of the basin reflect the climate of the various regions. In the headwaters the streams are largely snow fed, with peak flows extending well into the summer as the snow fields of the high peaks continue to melt. Down through the wide plains areas the streams are dependent upon rainfall except for the brief spring break up, with the result that they flow full or nearly so during the spring months when the winter accumulation of ice and snow melts away, and during the spring rains, and then go nearly dry during the summer and fall. During drought years, as the decade of the thirties, many of the streams do go completely dry for extended periods, and others fade away to a few pools with intermittent flow between them. Only in those streams with headwaters in the snow fields is summer and fall flow maintained at any substantial level, and the long channels through pervious soils permit much of this flow to escape into the subsoil. Further south and east the rainfall becomes sufficient to maintain streams during year round flow. In many cases groundwater storage and return flow is an important factor in maintaining late summer and fall flows, and even drought period flows. An outstanding example of this is the Niobrara River which, flowing through the northern Nebraska sand hills, seldom rises very high, but always has a dependable flow. The protracted drought of the thirties had relatively little effect upon this stream.

On the main stem there are two well defined flood periods. The first of these is referred to as the "March" rise, and is caused by the spring break up, and the melting of the snow cover on the Great Plains during the early spring rains. The second is referred to as the "June" rise, and is caused by the melting of the snow in the mountains under the late spring and early summer rains, and by the spring and early summer rains over the Great Plains. Either may be serious, depending upon the amount of snow cover in the contributing area, the rapidity of the melting, and the amount of the accompanying rains. The June rise in particular is often augmented by widespread heavy rains over the eastern plains and the lowlands of the eastern part of the basin. Several severe floods of the lower basin have been caused by such heavy rains on the lower tributaries, runoff from which was added to substantially normal flows from the upper river.

NATURAL RESOURCES: The Missouri River Basin has a variety of mineral resources. These include copper, lead, gold, and silver in the mountain areas; more lead and some zinc along the edge of the Ozark Plateau; some petroleum in the southern part of the basin (the large mid-continent fields lie just south of the Missouri River Basin) and in Wyoming; rock suitable for construction purposes at many places through the basin, including ornamental rock, and extensive deposits of a carbonate manganese ore in southeastern South Dakota. Raw materials for ceramic industry are found in many parts of the basin, and there are large deposits of lignite coal in the Dakotas. Mining is an important industry in the mountain areas, and the lead, zinc, and petroleum of the southern part of the basin are being developed. Construction materials, lignite coal, and ceramic products are generally processed for the immediate area only. No economically competitive method has yet been developed for the reduction of the manganese ore of South Dakota; this ore is, however, being studied by the U. S. Bureau of Mines with a view to developing feasible, economical procedures by which this material may compete in price with foreign manganese.

There are extensive timber lands in the mountainous areas of the headwaters, and in the Black Hills. There is also some commercial timber in the southeastern part of the basin. Elsewhere in the basin timber is of relatively little importance commercially.

Another important natural resource is simply the power of falling water. In the mountainous headwaters important blocks of hydroelectric energy are being developed, under both private and governmental agencies. Further development is planned. In the flatter regions of the basin conditions are not so favorable to the development of water power, but modern low head turbines with high efficiencies over wide ranges of head are capable of making effective use of the storage available at any reservoir site feasible of development on the main stem, and on many of the tributaries. The generation of hydroelectric power at such sites is planned.

The greatest single natural resource of the Missouri River Basin is the soil. Over by far the greater part of the basin the soil is fertile and, topography and available moisture permitting, well adapted to agricultural development of many types. Well planned soil conservation procedures and irrigation developments are continually bringing greater areas into production. The soil supports not only the agricultural industry of the basin, but also the numerous industries which are based upon the processing of agricultural products for a continuously expanding range of uses.

INDUSTRY: The Missouri River Basin being an important agricultural area, it is natural that a great part of its industry should be based upon the processing of agricultural products. Such industries include meat packing, with its many related industries; the processing of dairy products; milling; the production of industrial starches, alcohols, and fibers, and the related rapidly expanding chemurgic industries; and the preparation of food products of all kinds for storage, shipment, and consumption. Other important industries include ceramics, woodworking, light manufacturing and assembly, and the fabrication of construction materials. There are no heavy industries in the basin, such as the large scale reduction of metal ores, blast furnace and rolling mill operation, and heavy assembly, although important quantities of copper ore are mined and partially processed in the mountain areas at and near the headwaters of the Missouri River.

TRANSPORTATION: A well knit system of varied transportation facilities covers practically the entire Missouri River Basin. Railroads cross the mountains on the west in routes west from Denver, Colo., Cheyenne, Wyo., and Billings, Mont. These cities are interconnected, and rail routes east from them expand into a network connecting Bismark, N. Dak., Pierre, S. Dak., Omaha, Nebr., and the Kansas Cities, Mo. and Kans., with St. Louis, Mo., Rock Island, Ill., Chicago, Ill., Minneapolis-St. Paul, Minn., and eastern points. Connections from Denver, Kansas City, and St. Louis also extend southward to Santa Fe, N. Mex., Dallas, Tex., Tulsa, Okla., Little Rock, Ark., Memphis, Tenn., and southern points. A well developed system of primary and secondary roads also covers the basin, supplementing and extending the facilities of the railroads, and furnishing all weather access to practically all communities. Good farm to market roads are also available through most of the basin. The Missouri River has been improved for navigation as far upstream as Omaha, and some improvement has been made as far upstream as Sioux City, Iowa, an important trade and transportation center. This improvement is continuing, work having been recently resumed after a shutdown to conserve critical materials and manpower during the war. The basin is also crossed by several transcontinental air routes, which are supplemented by numerous feeder lines. All larger cities have airports, and many smaller communities are providing facilities for air transportation.

POPULATION: The population of the Missouri River Basin varies in intensity with the intensity of agriculture and with the degree of industrial development. In the northwestern mountain states of Montana and Wyoming the average population is approximately 5 per square mile. Proceeding southeastward the more intensive agricultural practices and the greater industrial development support a greater unit population. The Great Plains region states have an average population of approximately 14 per square mile. The cities of Denver, Colo., Pueblo, Colo., Sioux City, Iowa, Lincoln, Nebr., Council Bluffs, Iowa, Omaha, Nebr., and Kansas City, Mo.-Kans., are classed as centers of metropolitan areas by the U. S. Bureau of the Census . St. Louis, Mo., while not in the basin geographically, lies at the mouth of the river, and is quite important to the transportation and industry of the region.

The total population of the nine states, parts of which make up the Missouri River Basin, is, according to the 1940 Census, 12,622,184, which is approximately 9.1 per cent of the total population of the United States. The average population intensity of all of the states of the basin is 12.1 per square mile, as compared with a national average of 44.2 persons per square mile.

WATER USE PROBLEMS

IRRIGATION: Throughout the semi-arid regions of the Missouri River Basin the use of water for irrigation is a practical necessity to successful

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crop farming of any sort. In many areas hay meadows are also irrigated by overflow which, if not produced naturally by spring floods, is caused by diversion dams and wiers. Irrigation procedures are also resorted to to increase yields and insure production in wide areas of the sub-humid regions, and to some extent throughout the basin. In 1939, according to the U. S. Bureau of the Census, there were 2,003,522 acres under irrigation above Sioux City, Iowa, in the Missouri River Basin, and 2,399,590 acres under irrigation below Sioux City; a total irrigated area within the basin of 4,403,112 acres. On the basis of an irrigation diversion of 3.0 acre feet per acre, this acreage would require an annual diversion of approximately 13,200,000 acre feet of water. Since approximately half of this will be returned to the stream through ground water flow, this amounts to a net annual depletion of approximately 6,600,000 acre feet of water for irrigation. These figures give an idea of the importance of irrigation farming in the basin. On the basis of slightly over 40 acres of irrigated land per family, it may be estimated that there are 100,000 families in the basin which are to a greater or less extent directly dependent upon irrigation.

A wide variety of crops are grown under irrigation. Probably the simplest irrigation procedure is the overflow irrigation of hay lands mentioned above; such lands are also irrigated by ditch. Other irrigated crops of wide importance include sugar beets, grain, forage crops, fruit, and truck garden produce, depending upon the climate and the demand of the local area involved, or the shipping facilities at hand.

General irrigation has been practiced as far east as Williston, N. Dak., in the northern part of the basin, and Kearney, Nebr., in the more southern part. Successful irrigation ventures have been carried on further east in some areas. However, as the humid area is approached, the overhead items of ditch maintenance and water charges become more burdensome in relation to the regular additional return from irrigation farming, and irrigation is not necessary at all for long periods during which higher rainfall prevails. These conditions lead to a breakdown of proper irrigation practices on the part of the individual farmer, and a reluctance to bear the fixed charges, even though a small amount of water during a critical period will sometimes save an entire crop from otherwise disastrous loss, even in the most humid regions. Because of these attitudes, irrigation projects east of about the 100th meredian should be developed cautiously, until it is clearly established that the crops proposed and the local conditions are conducive to profitable operations over an extended period, so that farmer cooperation is assured.

NAVIGATION: Navigation has in the past been of great importance to the development of the Missouri River Basin. Regular trips were formerly made as far upstream as Fort Benton, Mont. The present head of navigation is Fort Peck Dam, because of the absence of locking facilities to bypass this structure. Improvements for the provision of a stabilized channel below Sioux City, Iowa, were under development prior to the war, and have now been resumed to the extent permitted by the material and manpower situations. Before the war oil barges were making use of unloading facilities a few miles below Sioux City, and an extensive terminal was in operation at Omaha, Nebr. A well developed traffic existed as far upstream as Kansas City, Mo., and is expected to be resumed as operating equipment, diverted for war time service on the better developed channels of the nations inland waterway system, is again put in service on the Missouri River.

Navigation of the Missouri River is expected to require a dependable discharge in the order of 25,000 cubic feet per second throughout the eight month navigation season, as measured in the vicinity of Sioux City, Iowa. This amounts to approximately 12,000,00 acre feet of water per season.

The extension of navigation into new areas involves many technical and economic problems. Among the former are the estimates of flow required to maintain project depths through the channel developed; the type of improvement, whether open river or slack water canalization, and the type of works best suited to bring about the selected manner of improvement. The latter include the existing freight rates, and the relation which these rates bear to the actual cost of transportation; the anticipated water borne freight rates; the nature of the available traffic, both actual and potential, and the importance of speed of delivery and the seasonal availability of river transportation. Also of importance is the public policy relating to the furnishing of competitive transportation as a means of stimulating the efficiency of existing transportation facilities, and as a backlog in the event of transportation emergencies. As a case in point the inland waterway system has been of tremendous value in the handling of heavy, slow commodities during the war, and in access to inland manufacturing facilities for the production of ocean going craft.

The large expenditures involved in the development and maintenance of a navigation channel, not only direct, as incident to the work itself, but indirect, as incident to the provision of increased bridge

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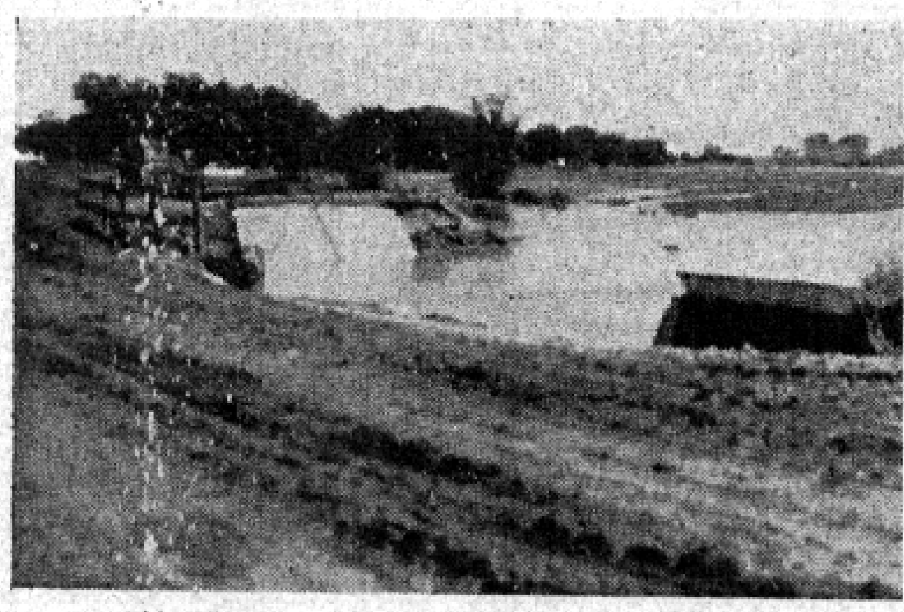
clearances and the development of suitable handling and transfer facilities, and the heavy water demand required for the maintenance of navigable flows, must both be carefully considered and found reasonable with relation to the benefits to accrue through reduced transportation costs, stimulated economy, and incidental items, such as channel stabilization, before an extension of navigation facilities can be regarded as economically feasible.

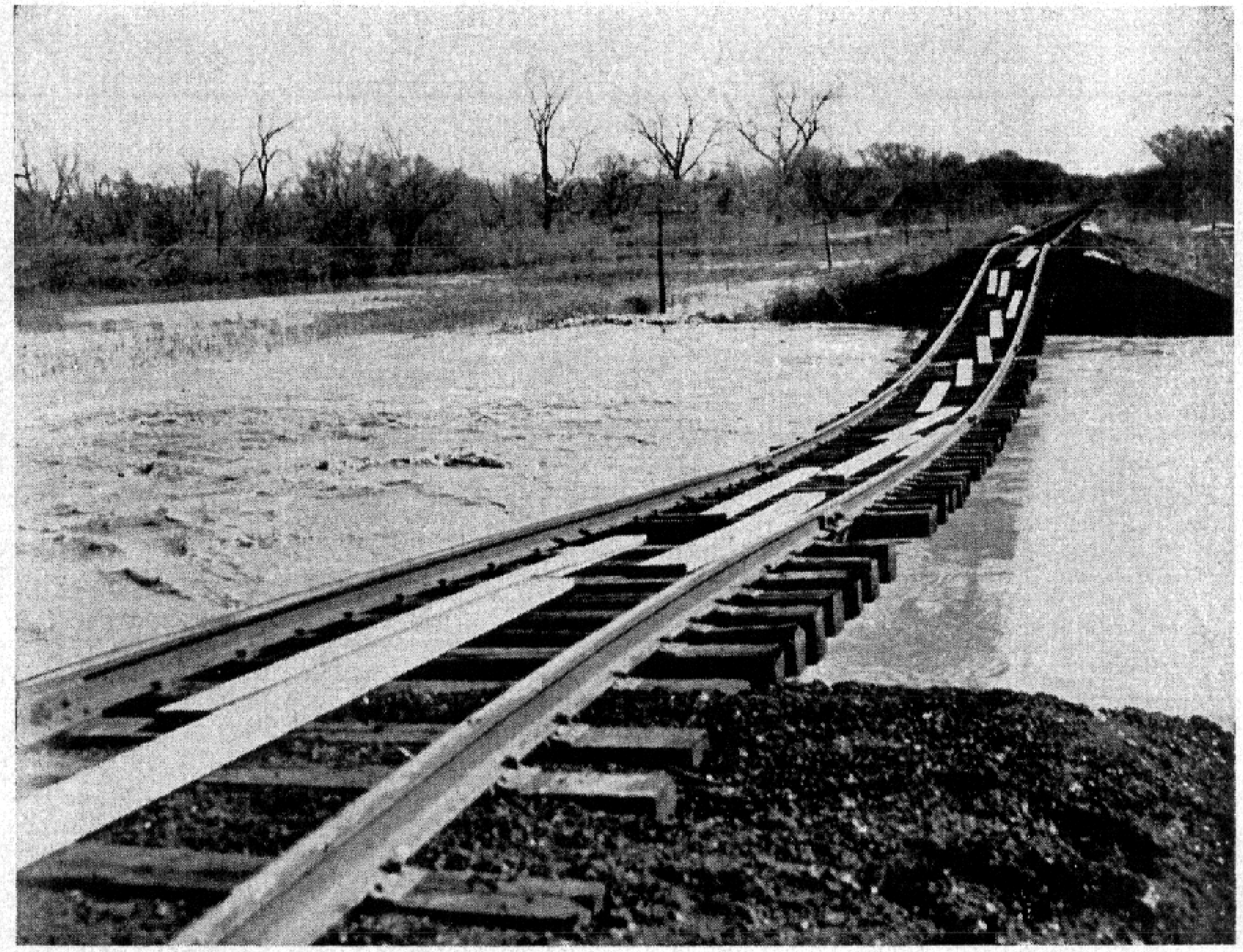


Flood damage to U. S. Highway No. 30 east of Blair, Nebraska, April 1944 flood. U. S. E. D. Photo.

Emergency flood protection work on rural levee east of Blair, Nebraska April 1944 flood. U. S. E. D. Photo.

FLOOD CONTROL: Flood control is a water use in a negative sense only, in that it must be considered in any plan of river development, but constitutes no consumptive demand on stored water. It is, however, a very important problem, and does require the setting aside of storage capacity. In the Missouri River Basin the annual flood losses are truly tremendous. A great portion of such losses occurs along the smaller streams, and individual damages are relatively small in the loss of crops and occasional livestock. Aggregate flood losses can not be tabulated, as no systematic reports of minor tributary floods are collected. It has been estimated, however, that in the Missouri River Basin main stem and urban flood damages have in recent years run as high as $65,000,000 (in 1943). While detailed figures are not available, a long term average annual flood damage figure of $4,000,000 to $5,000,000 for main stem and urban damages alone is indicated to be conservative.

Main stem agricultural and urban damages are aggravated by the fact that during periods of low flow, such as the drought years of the 1930's, inhabitants of the valley tend to encroach upon the normal floodway of the stream, both in rural areas and in cities. Upon the recurrence of normal and above normal rainfall, and resulting increased



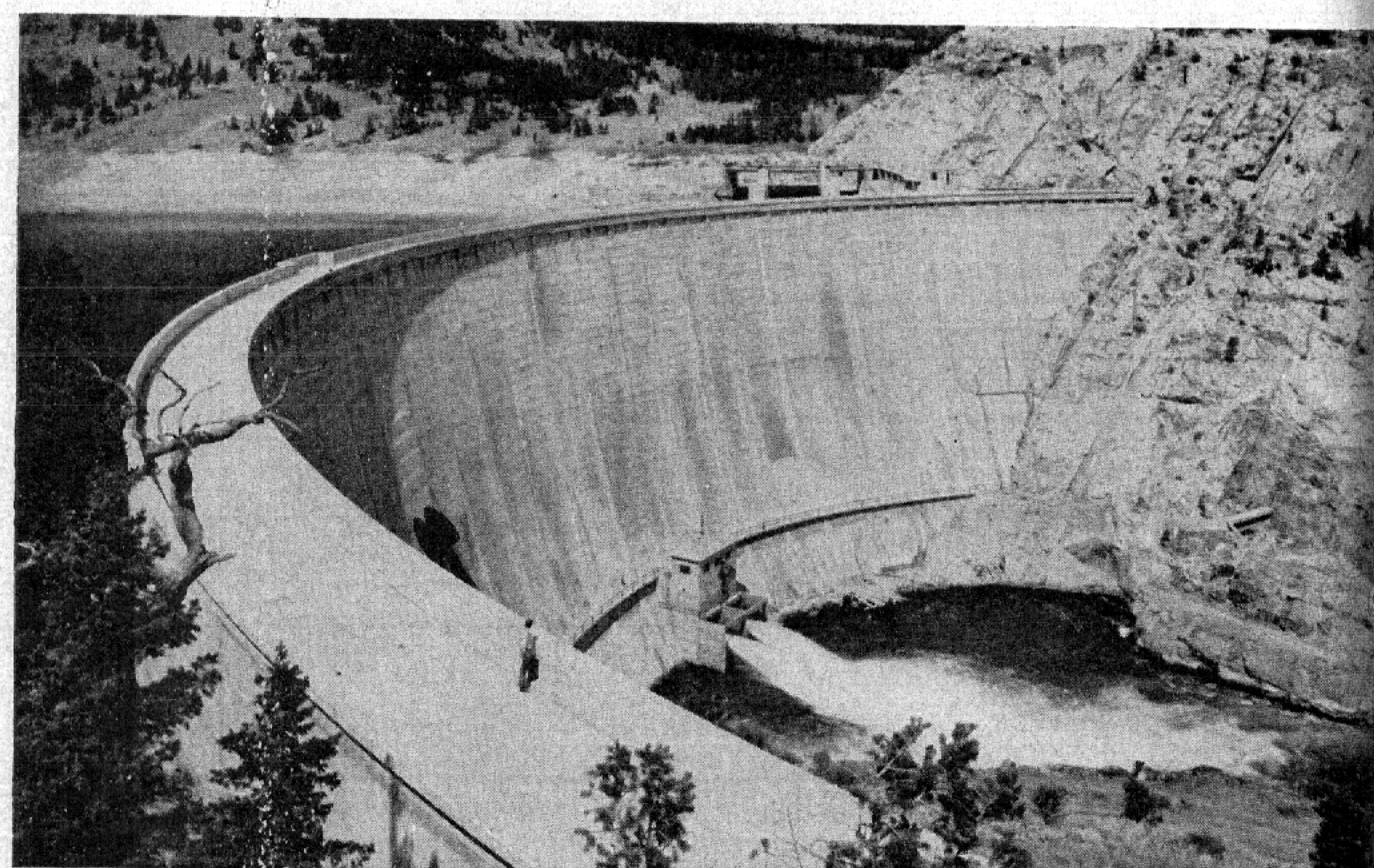
Railroad wash-out a few miles east of Blair, Nebraska April 16, 1944. Omaha World Herald Photo.

streamflow, the rural developments in the floodway are flooded out, and the urban developments are not only flooded, but also often seriously aggravate local flood peaks due to the confining effect which they have upon the waterway. This situation is still further complicated by the well established tendency of a stream flowing at below normal discharges to deposit unusual amounts of sediment in its channel, because of its decreased carrying capacity. Upon the return or normal flows stages somewhat above normal are experienced until the stream has had time to scour out its channel to the former capacity.

The magnitude of direct and indirect flood damages makes it imperative that every effort be made to control the discharge of flood flows, both through the means of levees to protect against high stages, and storage reservoirs to decrease the stages. On a stream having the alluvial plain characteristics of the Missouri River it is not feasible to build levees high enough to protect against upstream discharges without

condemning excessive valley widths for the floodway. For this reason reservoir capacity to reduce such discharges to controllable volume are required. On the other hand, such reservoirs cannot protect against intense rainfall and resulting high runoff which takes place in downstream areas. Since there are no suitable reservoir sites below the vicinity of Yankton, S. Dak., levees for the protection of valley lands below this point are indicated.

HYDROELECTRIC POWER: Hydroelectric power is not a consumptive use of water. It is, however, a means of utilization of the head normally available at reservoirs which are constructed for the storage of water for other purposes, within certain limits. At favorable sites it is possible to maintain a dependable power head of significant proportions, and still have available the storage required for the handling of flood flows, and for other purposes. At several locations along the main stem of the Missouri River there exist power potentialities, and likewise a prospective demand for large blocks of power for various industrial, agricultural, and domestic uses.



Gibson Dam across the Sun River in Montana. Picture from Civil Engineering, Nov. 1944.

In the design of hydroelectric power developments on a river such as the Missouri it is necessary to take full account of the several water use requirements. The height of the power pool must not be allowed to encroach upon the storage capacity required for adequate flood control. The requirements of the power demand must not be permitted to interfere with the meeting of normal irrigation requirements. Navigation flows, representing a heavy investment in plant and facilities which is worthless without water, must be maintained. Domestic water supply and sanitary requirements must be met.

DOMESTIC WATER SUPPLY AND SANITATION: In the upper, semiarid regions of the Missouri River Basin the supply of domestic water is a critical problem. In many cases such supplies are obtained from ground water, or from the collection of rain water. In other cases, however, rivers may be used as a source of supply. When rivers are available for domestic water supply this use has widely recognized priority on the water available. Since the population in these areas is in general sparse, sewage disposal problems are not ordinarily difficult, and what little discharge there is into the streams is not generally a serious problem.

In the lower part of the basin both of these problems become very important in some areas. The large cities along the main stem all secure their water supplies from the Missouri River, and all discharge their sewage into the stream, with relatively little if any treatment. In order to maintain a stream of sufficient purity that water supplies taken from it will not require excessively expensive treatment, and in order to prevent the creation of a serious nuisance below sewer outfalls, it is mandatory that a certain minimum flow be maintained at all times. Because of the greater activity of microscopic organisms at higher temperatures, and the resultant higher biochemical oxygen demand at such temperatures, this minimum flow is higher in the summer months than in the winter. The maintenance of this flow at the appropriate seasonal minimum is a health problem of great importance.

DIVERSION PROJECTS: Immediately north and east of the Missouri River Basin, in eastern North Dakota, western Minnesota, and northeastern South Dakota, in the watersheds of the Souris, Sheyenne, and James Rivers, the Red River of the North, and Devils Lake, there exist from time to time critical water use problems as described above, particularly with respect to domestic water supply and stream sanitation.

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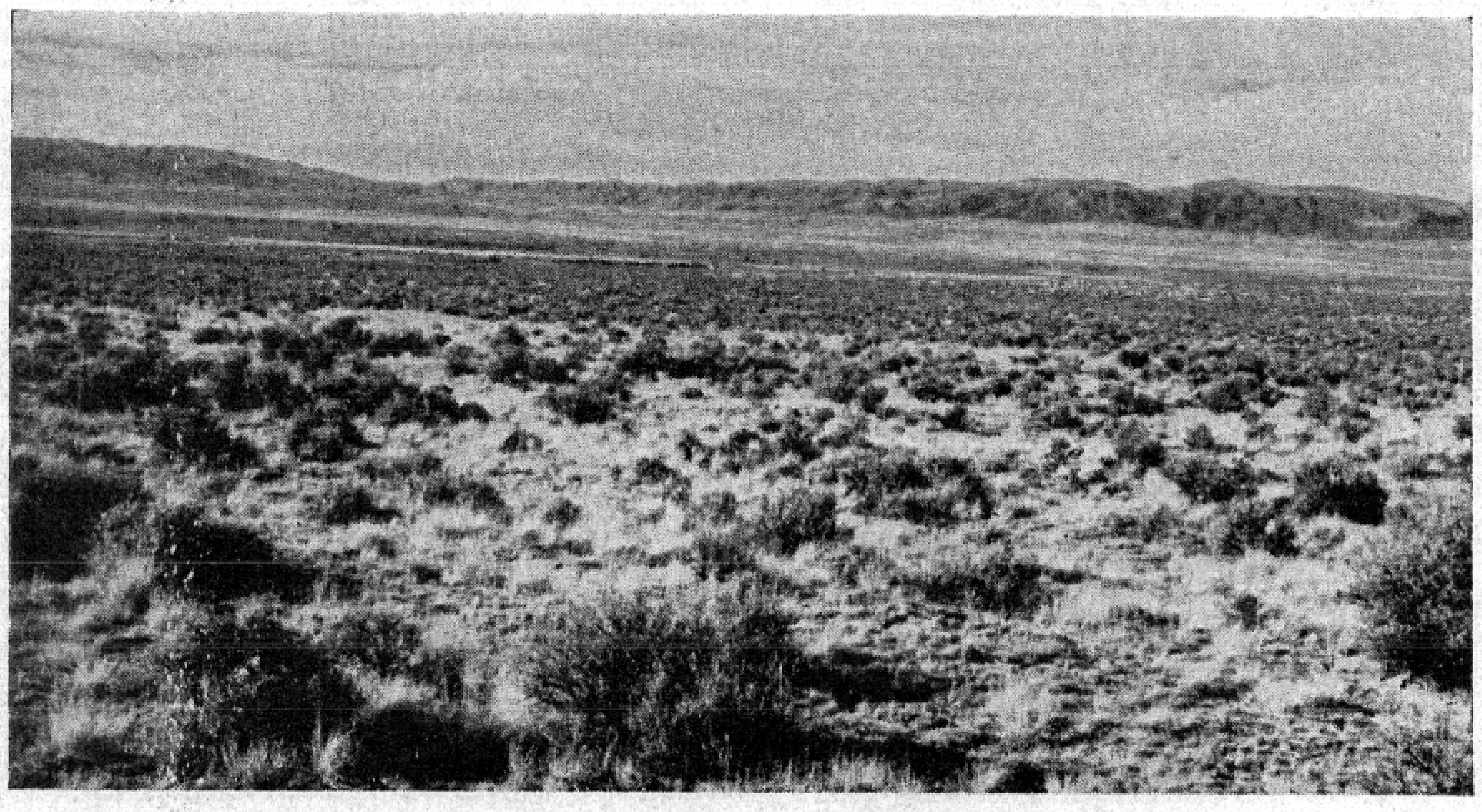
During drought periods, such as the 1930's these streams fall off to an alarming extent. Long reaches cease to have any flow at all, degenerating into a series of pools with no connecting flow. Further upstream the water courses go completely dry. This situation is accompanied by a falling water table, so that water supply of any kind is extremely difficult. Municipal resources are taxed to the utmost to provide bare necessities, and fire reserves fall dangerously low. Industrial water users are seriously hampered, or put out of operation completely from time to time. Sewage discharges into the practically dry streams produce nuisance conditions that are not only quite unpleasant, but a positive menace to health. Pools stagnate, and what little flow there is is so polluted that natural recovery is very slow.



Good Sagebrush lands which can be brought under cultivation with the extension of irrigation. Picture from Civil Engineering, Nov. 1944.

Recreational facilities also suffer severely. The outstanding example is Devils Lake, in eastern North Dakota. Formerly having an area of approximately 93,500 acres, with an area of 50,000 to 55,000 acres in the early 1900's, this body of water fell steadily for many years. During the drought years it reached a low of approximately 4,350 acres, at the same time falling in level more than 30 feet from known elevations.

During this process the water became so heavily mineralized that aquatic life was practically exterminated; only a few very simple forms of algae persist. The mud flats around the shrunken lake developed a strongly disagreeable odor and, upon drying, became the source of clouds of alkali dust which killed vegetation for considerable distances back from the shore.

All of these problems have led to the development of a very strong feeling in this area in favor of diversion of water from the Missouri River for delivery into these streams. A variety of methods of doing this have been proposed. One group of plans would divert from the Missouri River in eastern Montana or western North Dakota by gravity and pump into the Souris River in western North Dakota, rediverting from this stream to the James and Sheyenne Rivers, and to Devils Lake. The Sheyenne River being a tributary of the Red River of the North, the requirements along the latter stream would be capable of fulfilment by adequate diversions into the Sheyenne River. Another group of plans would divert from the Missouri River in central North Dakota by gravity and tunnel from a high dam and reservoir, or by gravity and pump from either a high dam and reservoir or from a low dam and reservoir, the latter being in some plans little more than a control weir. Diversion flows from these proposals would be into the headwaters of the James and Sheyenne rivers, and water for the Souris River and Devils Lake would be taken from the canal system and the Sheyenne River, respectively.

All of these diversion schemes are based upon the unusual relative elevations noted under the General Description above. Because of their important effect upon low water flows during periods of protracted drought they must be considered in any truly comprehensive plan for the development of the Missouri River Basin water resources even though, of all the streams involved, only the James River is a tributary of the Missouri River. Return flows through the James River would be of little significance in these diversions.

Other diversions into the lower James River valley have been proposed for irrigation purposes. However, the behavior of such projects would be similar to any large irrigation development, so that they are little different from equivalent valley irrigation in their effect upon long range planning.

THE EVOLUTION OF THE PLAN

The plan described herein is primarily the work of the U. S. Engineer Department and the U. S. Bureau of Reclamation, working in

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cooperation with other governmental agencies. These agencies include the Federal Power Commission, the U. S. Public Health Service, the U. S. Fish and Wildlife Service, and other Federal agencies. The views and desires of the States and of local interests are determined in a variety of ways by the various agencies. In order to indicate the basis upon which this plan was developed, a brief historical outline is given, covering the activities of the two principal agencies as they pertain to the Missouri River Basin.

EARLY ACTIVITIES OF THE U. S. ENGINEER DEPARTMENT: The U. S. Engineer Department began to be concerned with the Missouri River shortly after the Louisiana Purchase of 1803 and the explorations of Lewis and Clark in 1804-06, since these events were soon followed by early, primitive navigation on the stream. As the area developed, navigation improved. In 1832 the improvement of critical points along the river was initiated. In 1884 the Missouri River Commission was organized, with jurisdiction over the work of the Engineer Department in the basin. Although the Commission never had the funds to carry out its program in full, the principles which it formulated have been followed closely in subsequent improvements up to the present time. The Missouri River Commission was discontinued in 1902, and the work of carrying out navigation improvements reverted to the District and Division organization of the Engineer Department which, with various modifications of jurisdictions of the several offices, has been maintained to the present. The work of this early period was in general limited to the dredging of critical bars, the improvement of harbors, and the pulling of snags. These operations were carried on from the mouth of the river to Fort Benton, Mont. Funds were never made available for a systematic improvement of the entire river during this period.

EARLY ACTIVITIES OF THE U. S. BUREAU OF RECLAMATION: The U. S. Bureau of Reclamation was set up, originally as the Reclamation Service, by the Reclamation Act of 1902, for the specific purpose of reclaiming the arid and semi-arid regions of the western United States through the construction of reservoirs, canals, laterals, and other appurtenances. Provision was made for the use of certain public funds, set up in the Reclamation Fund, which would be repaid by the districts to be organized to take over the operation of the completed projects. The operations of the Bureau of Reclamation are by statute limited to the states lying in whole or in part west of 98th meredian. Early operations consisted of the development of supplemental water for existing projects, the coordination of such projects, the development of new projects,

and the development of new areas. Through these activities the irrigation of important new areas has been possible.

"308" REPORTS: The "308" reports are a series of reports covering most of the rivers of the United States. They were authorized by the River and Harbor Act of 1927, and take their designation from the fact that they were all listed in House Document No. 308, 69th Congress, 1st session. The specific purpose of these reports was to study each watershed "with a view to the formulation of general plans for the most effective improvement of such streams for the purposes of navigation and the efficient development of the potential water power, the control of floods, and the needs of irrigation—". Following the disastrous floods of 1927 on the Mississippi River, the Flood Control Act of 1928 directed that the "308" reports covering the Mississippi River system include special consideration of flood problems on that stream. The "308" reports for the Missouri River and for its tributaries contain a basin wide plan for the accomplishment of these objectives, based on the information available at that time; the last "308" report relating to the Missouri River Basin, the main stem report which summarized all the tributary studies, was submitted to the Congress in 1933. While prepared by the U. S. Engineer Department, these reports included important data developed by cooperating agencies which included the U. S. Bureau of Reclamation and the Federal Power Commission.

The "308" reports do not include a description of the presently authorized plan, as has been erroneously implied by some of the discussions recently published with reference to the development of the Missouri River Basin. The extensive studies made for these earlier reports have been utilized in the more recent studies, and many of the individual projects recommended before have been found to be suitable for inclusion in the present plan. This present plan may be described as an up to date, extensive revision of the "308" plan to meet current and future needs as determined by the U. S. Engineer Department and the U. S. Bureau of Reclamation in view of recent developments, and in cooperation with other interested agencies, including the Federal Power Commission, the U. S. Department of Agriculture, the U. S. Public Health Service, and the U. S. Fish and Wildlife Service.

INTER-DEPARTMENTAL AGREEMENTS: In order to coordinate the activities of the various Federal agencies interested in the development of the nation's water resources, there have been in effect for several years certain agreements. The first of these was often referred to as the Tri-Partite Agreement. It was entered into by the U. S. Engineer

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Department, the U. S. Bureau of Reclamation, and the U. S. Department of Agriculture in 1939 for the specific purpose of providing for a regular exchange of data on the projects in which more than one agency was interested so as to coordinate the studies of the several agencies and avoid wasteful duplication of effort. Periodic meetings of the representatives of the three agencies were provided for. In 1943 this agreement was superseded by the so-called Quadri-Partite Agreement, entered into by the same three agencies and the Federal Power Commission. This agreement, operating in the same manner as the former, is in effect today, with regular coordinating conferences of the four agencies concerned.

House Document No. 475: As the developments of recent years indicated that extensive action was required to utilize properly the potentialities of the Missouri River, various studies were undertaken looking toward the planning of such action. One of these was in response to a Congressional directive for a review of previous reports for flood control from Sioux City, Iowa, to the mouth (resolution of the Committee on Flood Control, House of Representatives, adopted May 13, 1943), to determine whether any revision was advisable. This request was prompted by the serious floods of early 1943. House Document No. 475, 78th Congress, 2d session, the so-called "Pick-Plan", was the result. This report recognized that in order to insure adequate flood protection, consistent with other beneficial uses of the river, it would be necessary to construct a series of levees along the main stem of the Missouri River from Sioux City to the mouth and, in order to prevent excessive levee heights and floodway widths, reduce the flood crests by a series of upstream reservoirs, the storage capacity and head of which might also be used to provide domestic and sanitary water requirements, irrigation and navigation flows, and hydroelectric power. This plan was presented as a basic framework, including the main stem and principal head-water reservoirs only. These structures or their equivalent were considered to be mandatory to a full utilization of the tremendous natural resource which is the Missouri River. Detailed plans for tributary development were not included for two reasons. Such plans were not within the scope of the report as indicated in the Congressional directive, and it was considered that, having the main stem reservoir system established, an expanding economy of the area might be anticipated, so that long range detailed plans would of necessity be subject to considerable revision as the principal features of the plan were constructed. After review and comment by interested agencies, this document was submitted to the Congress by the Secretary of War on December 31, 1943.

Senate Document No. 191: While the U. S. Engineer Department was engaged in the preparation of this plan of main stem development, the U. S. Bureau of Reclamation was also engaged in studies looking toward an overall plan for the Missouri River Basin within its field of action. Since any comprehensive plan must consider all water uses, this plan also considered large storage reservoirs on the main stem, and levees below Sioux City, Iowa. In the tributary areas the studies of the Bureau of Reclamation permitted a more accurate forecast of the probable future trends of irrigation development. Based on this information the plan prepared by this agency was considerably more detailed in so far as irrigation projects were concerned. Power developments at headwater reservoirs were also provided for. As might be expected from the plans of two agencies working on different phases of the same problem, there was substantial agreement on overall objectives, with minor differences on some specific features. Including more of the tributary projects, and extensive irrigation development, the plan of the Bureau of Reclamation called for considerably more work to be done; the plan of the Engineer Department contemplated somewhat more extensive development of the main stem. Different plans were provided for the supply of water to the diversion area of the eastern Dakotas. After review and comment by interested agencies, the plan of the Bureau of Reclamation, sometimes referred to as the "Sloan Plan", was submitted to the President by the Secretary of the Interior on May 1, 1944, and was presented in the Senate on May 5, 1944. It was printed as Senate Document No. 191, 78th Congress, 2d session.

Senate Document No. 247: During the summer of 1944 these two plans were widely discussed by the various Federal agencies, State agencies, and local interests concerned. On October 16-17, 1944, representatives of the two author agencies met in Omaha, Nebr., and, after a careful study of the points of difference between the two plans, prepared a combined plan including the common features of both, and reconciling the differences. The report of this conference, with further comment by the Chief of Engineers and the Commissioner of Reclamation, was presented in the Senate on November 21, 1944, and subsequently printed as Senate Document No. 247, 78th Congress, 2d session.

Public Law 534: The plan of development described in this document was approved, and initial phases were authorized, by the Flood

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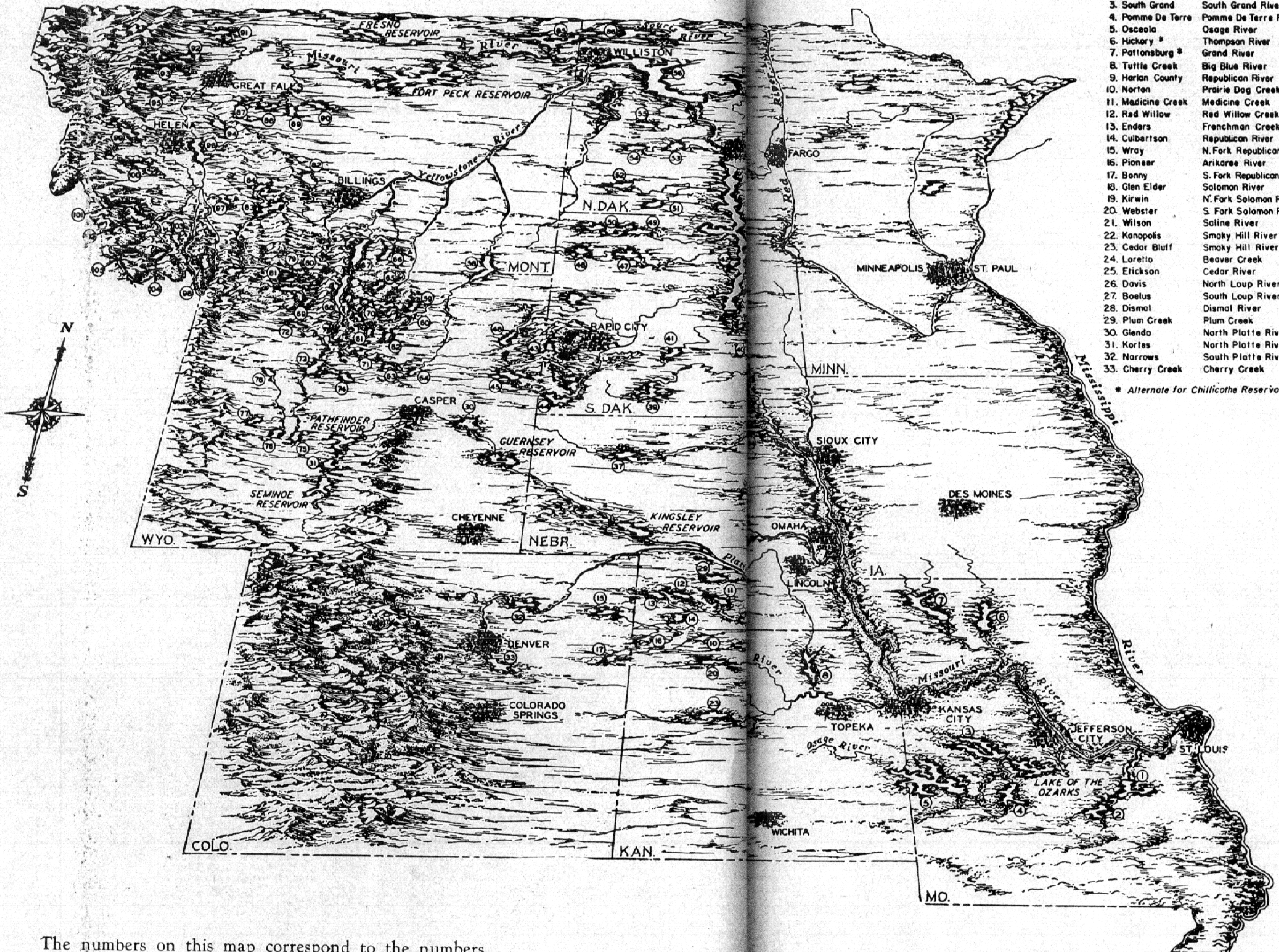
PROPOSED RESERVOIRS

RESERVOIR	STREAM
1. Aclington	Gasconade River
2. Richland	Gasconade River
3. South Grand	South Grand River
4. Pomme De Terre	Pomme De Terre River
5. Osceola	Osage River
6. Hickory *	Thompson River
7. Pattonsburg *	Grand River
8. Tuttle Creek	Big Blue River
9. Harlan County	Republican River
10. Norton	Prairie Dog Creek
11. Medicine Creek	Medicine Creek
12. Red Willow	Red Willow Creek
13. Enders	Frenchman Creek
14. Culbertson	Republican River
15. Wray	N. Fork Republican River
16. Pioneer	Arikaree River
17. Bonny	S. Fork Republican River
18. Glen Elder	Solomon River
19. Kirwin	N. Fork Solomon River
20. Webster	S. Fork Solomon River
21. Wilson	Saline River
22. Kanopolis	Smoky Hill River
23. Cedar Bluff	Smoky Hill River
24. Loretto	Beaver Creek
25. Etickson	Cedar River
26. Davis	North Loup River
27. Boelus	South Loup River
28. Dismal	Dismal River
29. Plum Creek	Plum Creek
30. Glendo	North Platte River
31. Kortes	North Platte River
32. Narrows	South Platte River
33. Cherry Creek	Cherry Creek
34. Gavins Point	Missouri River
35. Jamestown	James River
36. Bald Hill	Sheyenne River
37. Box Butte	Niobrara River
38. Fort Randall	Missouri River
39. Rocky Ford	White River
40. Big Bend	Missouri River
41. Philip	N. Fork Bad River
42. Oahe	Missouri River
43. Deerfield	Rapid Creek
44. Angostura	Cheyenne River
45. Edgemont	Beaver Creek
46. Keyhole	Belle Fourche River
47. Green Grass	Moreau River
48. Bixby	Moreau River
49. Blue Horse	Grand River
50. Shade Hill	Grand River
51. Thunder Hawk	Cedar River
52. Cannon Ball	Cannon Ball River
53. Heart Butte	Heart River
54. Dickinson	Heart River
55. Broncho	Knife River
56. Garrison	Missouri River
57. Sheyenne	Sheyenne River
58. Moorehead	Powder River
59. Lake De Smet	Piney Creek
60. Willow Park	S. Fork Piney Creek
61. Triangle Park	Rock Creek
62. Bull Creek	Clear Creek
63. Smith	N. Fork Powder River
64. Middle Fork	Middle Fork Powder River
65. South Fork	S. Fork Tongue River
66. Little Horn	Little Horn River
67. Yellowtail	Big Horn River
68. Kane	Big Horn River
69. Oregon Basin	Shoshone R. Offstream
70. Red Gulch	Shell Creek
71. Lake Solitude	Paintrock Creek
72. Anchor	S. Fork Owl Creek
73. Boysen	Big Horn River
74. Badwater	Badwater Creek
75. Onion Flat	Little Popo Agie River
76. Sorel Creek	N. Fork Popo Agie River
77. Raft Lake	N. Fork Little Wind River
78. Du Noir	Wind River
79. Sunlight	Sunlight Creek
80. Thief Creek	Clark Fork
81. Hunter Mtn.	Clark Fork
82. Sweetgrass	Sweetgrass Creek
83. Mission	Yellowstone River
84. Antelope	Shields River, Offstream
85. Medicine Lake	Big Muddy Creek
86. Crosby	Missouri R. Offstream
87. Stanford	Skull Creek
88. Hobson	Judith River
89. Ross	Ross Fork
90. Snowy	Cottonwood Creek
91. Tiber	Marias River
92. Wilson	N. Fork Sun River
93. Nilan	S. Fork Sun River
94. Newland	Newland Creek
95. Wells	Rock Creek
96. Canyon Ferry	Missouri River
97. Bridger	Bridger Creek
98. Taylor	Taylor Fork, Gallatin River
99. Terry	Boulder River
100. Whitetail	Whitetail Creek
101. Apex	Birch Creek
102. Kelley	Rattlesnake Creek
103. London	Blacktail Creek
104. Clark Canyon	Beaverhead River
105. Brenner	Horse Prairie Creek

* Alternate for Chillicothe Reservoir



The numbers on this map correspond to the numbers just before the names of the reservoirs in the tables beginning on page 27.

MISS BASIN

RESERVOIRS FOR FLOO AND ALLIED PURPOSES
INCLUDED IN PLANS A FLOOD CONTROL ACT.

OFFICE OF THE DIVISION ENGINEER. MISSOURI RIVER DIVISION
WAR DEPARTMENT JANUARY 1945

Hq 7SvC 3753 8 May 45 - 800

Control Act of 1944, Public Law 534, 78th Congress, 2d session, approved December 22, 1944.

House Document No. 214: The plan so authorized was primarily a flood control, irrigation, and power plan. The needs of navigation were provided for, but no specific proposals were included. The recommendations of the U. S. Engineer Department with regard to navigation had been previously presented to the Congress by the Secretary of War in 1938, and were printed at that time as House Document No. 214, 76th Congress, 1st session. This document recommended the provision of a 9 foot channel for open river navigation from the mouth of the Missouri River to Sioux City, Iowa, by the continuation and extension of the methods in progress on the 6 foot channel through this reach, systematic work on which was first authorized for the lower river only in 1912. These improvements consist of channel stabilization, the construction of suitable control works to confine the low water flow, revetment of banks, and such supplemental dredging as may from time to time be required to maintain the project depth at critical points.

Public Law 14: The construction of the 9 foot channel so recommended was authorized in the River and Harbor Act of 1945, Public Law 14, 79th Congress, 1st session, approved March 2, 1945.

An important provision of both the Flood Control Act of 1944 and the River and Harbor Act of 1945 should be pointed out. These acts specifically provide that in the preparation and submission of any report on a proposed improvement, such report shall be submitted to the Governor of the State or States concerned for comment. A period of 90 days shall be allowed for the submission of such comment. This is to be done as one of the last steps prior to the formal submission of the report to the Congress by the preparing agency. This supplements the established policy by which subordinate offices determine the desires of local interests through the means of public hearings as one of the first steps in the preparation of the report, and work with such public and private agencies as have any responsible interest in the conception and design of the improvements involved. While numerous instances from the past operations of the agencies concerned might be cited to demonstrate the efforts of these agencies to cooperate fully with local interests and agencies, this provision removes certain past legal restrictions, establishes a systematic procedure for full cooperation, and furnishes a further assurance that the desires of the people most concerned in the proposed improvements will be heard.

DESCRIPTION OF THE PLAN

For convenience of reference Senate Documents Nos. 191 and 247 both divide the Missouri River Basin into six regions, as follows:

I Upper Missouri River Basin
II Yellowstone River Basin
III Missouri River, Fort Peck to Sioux City
IV Minor Western Tributaries
V Niobrara, Platte, and Kansas Rivers
VI Lower Missouri Basin

The features of the plan of improvement are described for each region in the following paragraphs. These data are taken primarily from House Document No. 475 and Senate Document No. 191. Reference has also been made to the accompanying panoramic map, which was prepared in the Office of the Division Engineer, Missouri River Division, to earlier reports, and, to a limited extent, to unpublished information. It must be emphasized that all data are of a preliminary nature, being drawn from survey reports and similar advance studies. Definite project plans may in some cases lead to substantial variations from the preliminaries studies. However, it is not believed that any such changes will substantially alter the character of the overall plan.

Upper Missouri River Basin: The plan contemplates the construction of nineteen reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
87	Stanford	Skull Creek	3,000
88	Hobson	Judith River	10,650
89	Ross	Ross Fork	6,700
90	Snowy	Cottonwood Creek	3,000
91	Tiber	Marias River	915,000
92	Wilson	North Fork Sun River	160,000
93	Nilan	South Fork Sun River (offstream)	10,000
94	Newland	Newland Creek	10,000
95	Wells	Rock Creek	2,600
96	Canyon Ferry	Missouri River	2,000,000
97	Bridger	Bridger Creek	15,000
98	Taylor	Taylor Fork Gallatin River	20,000
99	Terry	Boulder River	10,000
100	Whitetail	Whitetail Creek	6,000
101	Apex	Birch Creek	3,000
102	Kelley	Rattlesnake Creek	5,000
103	Landon	Blacktail Creek	15,000
104	Clark Canyon	Beaverhead River	150,000
105	Brenner	Horse Prairie Creek	15,000
	Total for 19 reservoirs		3,359,950

The storage capacity of these reservoirs would be used for flood control, silt control, the development of hydroelectric power, and irrigation. Irrigation uses contemplate 460,900 acres of new lands, and the provision of a supplemental water supply for 208,700 acres of land now being served with an inadequate water supply. The development of hydroelectric power would be accomplished at the Canyon Ferry project listed above, and at power plants located at Lyons and at Portage.

YELLOWSTONE RIVER BASIN: The plan contemplates the construction of twenty-seven reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
58	Moorhead	Powder River	390,000
59	Lake DeSmet	Piney Creek	44,000*
60	Willow Park	South Fork Piney Creek	9,700
61	Triangle Park	Rock Creek	4,000
62	Bull Creek	Clear Creek	14,000
63	Smith	North Fork Powder River	30,000
64	Middle Fork	Middle Fork Powder River	50,000
65	South Fork	South Fork Tongue River	25,000
66	Little Horn	Little Horn River	50,000
67	Yellowtail	Big Horn River	470,000
68	Kane	Big Horn River	750,000
69	Oregon Basin	Shoshone River (offstream)	150,000
70	Red Gulch	Shell Creek (offstream)	13,000
71	Lake Solitude	Paintrock Creek	7,000
72	Anchor	South Fork Owl Creek	15,000
73	Boysen	Big Horn River	730,000
74	Badwater	Badwater Creek	7,500
75	Onion Flat	Little Popo Agie River	9,000
76	Sorral Creek	North Fork Popo Agie River	25,000
77	Raft Lake	North Fork Little Wind River	41,000
78	Du Noir	Wind River	220,000
79	Sunlight	Sunlight Creek	40,000
80	Thief Creek	Clark Fork	130,000
81	Hunter Mountain	Clark Fork	150,000
82	Sweetgrass	Sweetgrass Creek	12,000
83	Mission	Yellowstone River	890,000
84	Antelope	Shields River (offstream)	9,000
	Total for 27 reservoirs		4,285,200

*Increase in present capacity.

The storage capacity of these reservoirs would be used for flood control, silt control, the development of hydroelectric power, and irrigation. Irrigation uses contemplate 509,560 acres of new lands, and the provision of a supplemental water supply for 204,500 acres of land now being served with an inadequate water supply. The development of hydroelectric power would be accomplished at the Mission, Yellowtail, Boysen, Kane, Hunter Mountain, Thief Creek, and Sunlight projects listed above, and at power plants located at Bald Ridge and Tongue River.

MISSOURI RIVER, FORT PECK TO SIOUX CITY: The plan contemplates the construction of five main stem reservoirs and five tributary and offstream reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
34	Gavins Point	Missouri River	200,000
35	Jamestown*	James River	800,000
36	Bald Hill*	Sheyenne River	60,000
38	Fort Randall	Missouri River	6,200,000
40	Big Bend	Missouri River	250,000
42	Oahe	Missouri River	19,600,000
56	Garrison	Missouri River	17,000,000
57	Sheyenne*	Sheyenne River	850,000
85	Medicine Lake*	Big Muddy Creek	5,200,000
86	Crosby*	Missouri River (offstream)	230,900
	Total for 10 reservoirs		50,390,900

*Primarily diversion control structures.

It should be reiterated that the capacities given are tentative, especially for the main stem reservoirs. Final storage capacities will depend upon final pool elevations which are to be determined, or have been recently determined, on the basis of more detailed plans and cost estimates. Studies to develop this information are now in progress, and agreement has been reached on the elevation to which Garrison Reservoir is to be constructed. This main stem reservoir system was selected to most effectively serve the present and ultimate requirements of flood control, irrigation, navigation, hydroelectric power, and other uses. Other uses include the diversions into the watersheds of the Souris, Sheyenne, and James rivers and Devils Lake for the provision of domestic and municipal water supplies, stream sanitation, conservation, and irrigation. Hydroelectric power will be generated at all of the main stem dams, and at several of the diversion structures. The dam and power plant at Big Bend will be substantially a run-of-river project to utilize the head between Oahe Dam and Fort Randall Reservoir. The dam and power plant

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at Gavins Point will serve primarily to reregulate releases from the Fort Randall power plant, with incidental power generation, so as to permit flexible operation at Fort Randall without damaging surges being released downstream. The irrigation uses, including the diversion area projects, contemplate the development of 2,292,000 acres of new land.

MINOR WESTERN TRIBUTARIES: The plan contemplates the construction of fifteen reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
39	Rocky Ford	White River	70,000
41	Philip	North Fork Bad River	15,000
43	Deerfield	Rapid Creek	12,400
44	Angostura	Cheyenne River	160,000
45	Edgemont	Beaver Creek	45,000
46	Keyhole	Belle Fourche River	276,000
47	Green Grass	Moreau River	90,000
48	Bixby	Moreau River	90,000
49	Blue Horse	Grand River	50,000
50	Shade Hill	Grand River	134,000
51	Thunder Hawk	Cedar River	30,000
52	Cannon Ball	Cannon Ball River	40,000
53	Heart Butte	Heart River	110,000
54	Dickinson	Heart River	7,000
55	Broncho	Knife River	50,000
	Total for 15 reservoirs		1,179,400

The storage capacity of these reservoirs would be used for flood control, silt control, the development of hydroelectric power, and irrigation. Irrigation uses contemplate 212,980 acres of new lands, and the provision of a supplemental water supply for 11,300 acres of land now being served with an inadequate water supply. The development of hydroelectric power would be accomplished at the Heart Butte project, and the development of pumping power is planned at the Angostura project.

NIOBRARA, PLATTE, AND KANSAS RIVERS: The plan contemplates the construction of twenty-seven reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
8	Tuttle Creek	Big Blue River	1,830,000
9	Harlan County	Republican River	850,000
10	Norton	Prairie Dog Creek	16,000
11	Medicine Creek	Medicine Creek	32,000

12	Red Willow	Red Willow Creek	48,500
13	Enders	Frenchman Creek	93,200
14	Culbertson	Republican River	170,000
15	Wray	North Fork Republican River	7,000
16	Pioneer	Arikaree River	34,000
17	Bonny	South Fork Republican River	118,000
18	Glen Elder	Solomon River	304,000
19	Kirwin	North Fork Solomon River	174,000
20	Webster	South Fork Solomon River	165,000
21	Wilson	Saline River	262,000
22	Kanopolis	Smoky Hill River	450,000
23	Cedar Bluff	Smoky Hill River	272,000
24	Loretto	Beaver Creek	15,000
25	Erickson	Cedar River	20,000
26	Davis	North Loup River	380,500
27	Boelus	South Loup River	790,000
28	Dismal	Dismal River	30,000
29	Plum Creek	Plum Creek	384,000
30	Glendo	North Platte River	150,000
31	Kortes	North Platte River	5,000
32	Narrows	South Platte River	660,000
33	Cherry Creek	Cherry Creek	136,400
37	Box Butte	Niobrara River	36,160
	Total for 27 reservoirs		7,432,760

The storage capacity of these reservoirs would be used for flood control, silt control, and irrigation. Irrigation uses contemplate 1,284,060 acres of new lands, and the provision of a supplemental water supply for 21,804 acres of land now being served with an inadequate water supply. The possibility of additional new irrigation lands and of power development at some of these projects has also been noted.

LOWER MISSOURI RIVER BASIN: The plan contemplates the construction of seven reservoirs as follows:

	Reservoir	*Stream*	*Capacity (acre-feet)*
1	Arlington	Gasconade River	769,000
2	Richland	Gasconade River	600,000
3	South Grand	South Grand River	1,570,000
4	Pomme de Terre	Pomme de Terre River	600,000
5	Osceola	Osage River	6,000,000
6	Hickory	Thompson River	1,293,000
7	Pattonsburg	Grand River	1,240,000
	Total for 7 reservoirs		12,072,000

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The storage capacity of these reservoirs would be used for flood control, silt control, and other beneficial uses.

The plan also contemplates, as a complement to the reservoir system for the protection of the lower river, the construction of a levee system from Sioux City, Iowa, to the mouth. These levees have been tentatively specified to have a 10 foot crown width, both in agricultural and urban areas. Agricultural levees would have side slopes of 1 on 3 on the river side, and 1 on 5 on the land side, with a 2 foot freeboard above the design flood, after settlement. Urban levees would have side slopes of 1 on 3 on the river side and 1 on 4 on the land side, with a 3 foot freeboard above the design flood. This cross section is subject to modification where local conditions impose special problems; through areas of high property value, reinforced concrete flood walls will be provided in lieu of levees. The width of floodway and the height of the levee system will be designed so that, supplemented by the system of reservoirs described above for the main stem and the lower tributaries, protection will be provided against all past floods of record. Appropriate interior drainage facilities will be included.

As a third item applicable to this lower reach of the river, the plan contemplates the improvement of the stream for navigation. A 9 foot channel with a bottom width of 300 feet is authorized, and work is under way. While authorized under a seperate act, the improvements in connection with this channel are important to the flood control works, for they consist in large part of structures to stabilize the river. Such structures are necessary in any event to prevent the loss of levees through meandering of the river.

PRESENT STATUS OF THE PLAN

As stated above, this plan is now authorized by acts of the Congress. The primarily flood control features of the plan, with provision for irrigation, hydroelectric power, navigation, and other beneficial uses, were approved by the Flood Control Act of 1944, and immediate work on initial phases was authorized. The strictly navigation features of the plan were approved by the River and Harbor Act of 1945. Funds for planning have been made available to the U. S. Engineer Department and the U. S. Bureau of Reclamation, and to the cooperating agencies, and plans are under way.

A comprehensive mapping program of the lower river valley is in progress, which will soon provide complete coverage of the river reaches to be protected by the proposed levee system, and enable studies in connection therewith to be based on up to date, detailed information.

This mapping is by aerial photogrammetric methods, so that complete aerial photographs of the area covered are also available. In addition to this program, aerial photographs are also available covering the river valley above Sioux City, Iowa.

Operations have recently been resumed on the U. S. Engineer Department's program of river regulation, looking toward the stabilization, control, and improvement of the channel. Detailed planning for the 9 foot channel will be coordinated with the designing of the levee system.

Detailed survey and design work is in progress on the large main stem reservoirs; this work is being prosecuted by the U. S. Engineer Department. Site surveys, highway and rail access route surveys, subsurface investigations, town planning for construction camp facilities and permanent towns for operating personnel, and engineering studies of the embankments and major structures; all are in progress.

The U. S. Engineer Department, in cooperation with the U. S. Bureau of Reclamation and other interested agencies, is pressing studies to determine the exact elevations to which it is most feasible to construct these large main stem reservoirs. The maximum operating pool elevation for the Garrison Reservoir has been decided upon by the Missouri Basin Inter-Agency Committee, a joint agency which is further described below.

The U. S. Bureau of Reclamation is actively engaged in the preparation of plans for the construction of the tributary reservoirs included in the first phase of that agencies part of the authorized plan of development, and the development of the irrigation areas to be served by these reservoirs.

The Department of Agriculture is engaged in surveys and planning activities looking toward the development of erosion control programs, and improved land use practices.

The Federal Power Commission is cooperating with the U. S. Engineer Department and the U. S. Bureau of Reclamation in the design and layout of the power facilities incident to the main stem dams, and the larger tributary projects. The studies of this agency include such matters as the most efficient distribution of the power generated, the power demand of the areas involved, and the possibility of using the large blocks of power available for the development of new industries and the stabilization and enhancement of the existing economy.

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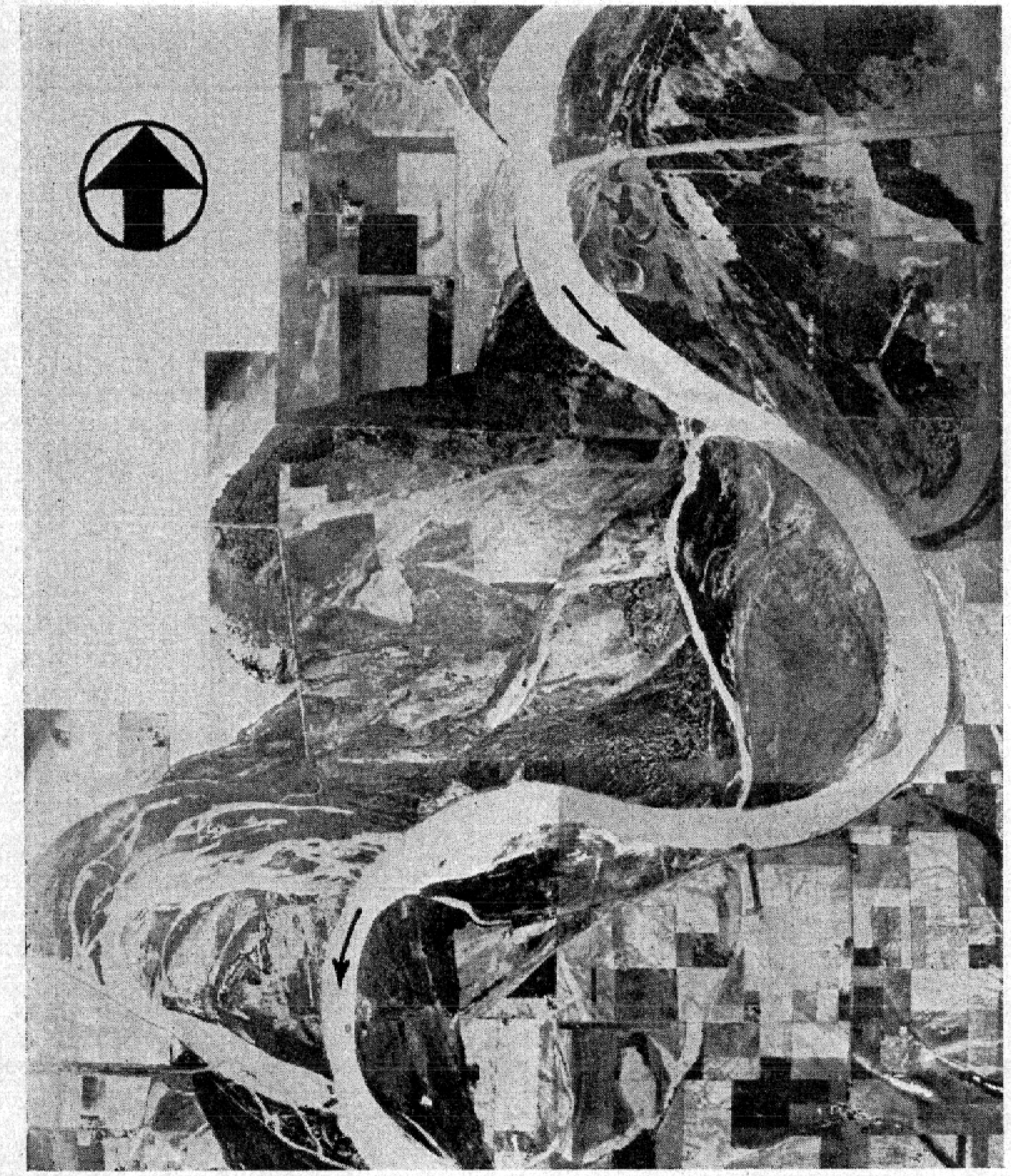
All of these activities are being coordinated and directed by the Missouri Basin Inter-Agency Committee. This committee consists of one representative from each of the agencies listed above, and four representatives from the Missouri Basin States Committee, an organization of the governors of the states parts of which make up the basin. This committee exercises an overall control of the work and, through monthly meetings, affords both frequent opportunities for the ironing out of problems which arise in the development of so large and involved a program, and continuing contact among the Federal agencies charged with the actual construction, and the elected representatives of the states involved.

River improvement work begun—a few structures in place, Bullard Bend, Soldier Bend, Peterson Cutoff, near Mondamin, Iowa, 1936. U. S. E. D. Photo.



Results of river improvement Bullard Bend, Soldier Bend, Peterson Cutoff, near Mondamin, Iowa, 1944. U. S. E. D. Photo.

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Editorially Speaking

RECONVERSION

The American public has gloated about the way American Industry was mobilized in time to win World War II. Forgotten is the unforgivable crime of our unpreparedness—except by those with Gold Star memories.

We are a great people!

Tragic smugness.

We are now engaged in another war—the War of Reconversion. We cannot understand why we are not solving its problems.

The reason we are not winning this War of Reconversion is the same reason we won World War II. Mass-production.

World War II was a *materiels* war—a tailor-made war for a nation with the *know-how* for mass-production.

The War of Reconversion is a war of *understanding*—a war that only an intelligent public can win easily. We do not have the know-how for this kind of a war, thanks to our mass-education methods.

Edmund Burke said, "Education is the cheap defense of nations."

Horace Mann said, "Schoolhouses are the republican line of fortifications."

But neither Burke nor Mann could have foreseen mass-production methods in education.

They must have conceived of the educated man as a different being than our present day specimen. They must have hoped that our statesmen and businessmen and engineers and ministers and doctors and lawyers would somehow get an education for Living.

They lacked the modern fine sense which abhors the extraneous. They didn't know anything about line-production methods. They couldn't conceive of one man being superbly trained to do *one* thing.

They expected a man to learn his profession after he had learned to Live. They had a case for Philosophy and Ethics and Political Economy and the Natural Sciences.

They would read with amazement that many Professional Schools are today talking about "liberalizing" their curricula.

But *they* would understand *why* we are unprepared for the War of Reconversion.

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